



Comparison and Performances of Pilot Based Channel Estimation Techniques for MIMO-OFDM System with Different Modulation Schemes

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ABSTRACT

Multiple input multiple output (MIMO) can be used to improve information carrying capacity in orthogonal frequency division multiplexing (OFDM). In MIMO-OFDM system channel estimation task becomes more difficult due to the change in channel parameter. Hence, to find appropriate channel estimation method which is able to follow changes at moment is matter of high significance. In this paper, types of adaptive algorithm for channel estimation in MIMO-OFDM system are discussed. Here we discussed two types of pilot transmission scheme. One is imposed type pilot and other is comb type pilot. We use different modulation scheme like BPSK, QPSK, 16-QAM, 64-QAM and compare comb type pilot's SNR vs BER to imposed type pilot's SNR vs BER.

Keywords : OFDM, Imposed – comb Pilot, Least square error, Minimum mean square error.

1 INTRODUCTION

Wireless communications is a rapidly growing segment of the communications Industry, with the potential to provide high-speed high-quality information exchange between portable devices located anywhere in the world. First, the demand of wireless connectivity is explosively increased. Second, the dramatic progress of VISL technology has enabled small-area and low-power implementation of sophisticated signal processing algorithm and coding algorithm. Second generation wireless communication standards, like CDMA, GSM, TDMA, make it possible to transmit voice and low volume digital data. Furthermore, third generation of wireless communications can offer users more advanced service that achieves greater capacity through improved spectral efficiency. Potential applications enabled by this technology include multimedia Internet-enabled Cell phones, smart homes and appliances, automated highway systems, video Teleconferencing and distance learning, and autonomous sensor networks. However, there are two significant technical challenges in supporting these applications: first is the phenomenon of fading: the time variation of the channel due to small-scale effect of multi-path fading, as well as large-scale effect like pass loss by distance attenuation and shadowing by obstacles. Second, since wireless transmitter and receiver need communicate over air, there insignificant interference between them. Overall the challenges are mostly because of limited availability of radio frequency spectrum and a complex time-varying wireless environment. In nowadays, the key goal in wireless communication is to increase data rate and improve transmission reliability. In other words, because of the increasing demand for higher data rates, better quality of service, fewer dropped calls, higher network capacity and user coverage calls for innovative techniques that improve spectral efficiency and link reliability, more technologies in wireless communication are introduced, like OFDM and MIMO.

2 MIMO - OFDM

Orthogonal frequency-division multiplexing (OFDM) is a method of digital modulation in which the data stream is split into N parallel streams of reduced data rate with each

of them transmitted on separate sub carriers. In short, it is a kind of multicarrier digital communication method. OFDM has been around for about 40 years and it was first conceived in the 1960s and 1970s during research into minimizing interference among channels near each other in frequency [2]. OFDM has shown up in such disparate places as asymmetric DSL (ADSL) broadband and digital audio and video broadcasts. OFDM is also successfully applied to a wide variety of wireless communication due to its high data rate transmission capability with high bandwidth efficiency and its robustness to multi-path delay [3]. OFDM has been proposed as a transmission method to support high-speed data transmission over wireless links in multipart environments. During the last forty years, OFDM has developed into a popular scheme for wideband digital communication, whether wireless or over wires, used in applications such as digital television and audio broadcasting, wireless networking and broadband internet access [4]. In wireless environments, transmitted signals follow several propagation paths. When reflected from surrounding objects these paths reach the receiver with different propagation delays that causes delay spread, inter-symbol interference (ISI), fading, and random phase distortion.

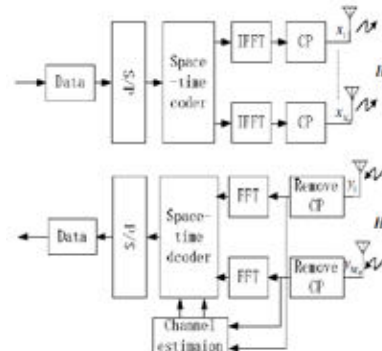


Figure 1: MIMO-OFDM System

MIMO OFDM is a technology that combines MIMO and OFDM together to Transmit data in wireless communications in order to deal with frequency selective Channel effect. The OFDM signal on each subcarrier can overcome narrowband fading, therefore OFDM can transform frequency-selective fading channels into parallel flat ones. Then by combining MIMO and OFDM technology together, MIMO algorithms can be applied in broadband transmission MIMO OFDM system transmits data modulated by OFDM from multiple antennas simultaneously. At the receiver, after OFDM demodulation, the signal are recovered by decoding each the sub-channels from all the transmit antennas MIMO OFDM will allow service providers to deploy a Broadband Wireless Access (BWA) system that has Non-Line-of-Sight (NLOS) functionality. Specifically, MIMO-OFDM takes advantage of the multipath properties of environments using base station antennas that do not have LOS. By combining both techniques, MIMO-OFDM can offer both robustness and high throughput. In a multiuser scenario where many users communicate with a central station (base station or access point), MIMO-OFDM becomes even more appealing because, it provides an additional opportunity to exploit due to many users the basic structure of MIMO OFDM is demonstrated. In this figure, the signals are modulated by OFDM modulator, then they are transmitted by MIMO system, finally, the signals are recovered by the OFDM demodulator. Therefore, MIMO OFDM achieves spectral efficiency, increased throughput and the inter-symbol interference (ISI) can thus be prevented.

3 CHANNEL ESTIMATION ALGORITHMS

Channel can be estimated at pilot frequencies by two ways:

1. (LS) Estimation
2. (LMMSE) Estimation

For block type arrangements, channel at pilot tones can be estimated by using LS or LMMSE estimation. Comb type pilot tone estimation, has been introduced to satisfy the need for equalizing when the channel changes even in one OFDM block.

A. LEAST SQUARE ESTIMATION

Without using any knowledge of the statistics of the channels, the LS estimators are calculated with very low complexity, but they suffer from a high mean square error. Suppose, X is pilot signal matrix, $(\cdot)^H$ is the conjugate transpose operation, H is specified channel condition matrix and Y is received signal matrix then for block type pilot structure, LS estimator minimizes the parameter $(Y-XH)H(Y-XH)$.

For block method, it is shown that the LS estimator of H is given by

$$H_S = [X_k / Y_k]^T \quad (1)$$

Where $k=0,1,\dots,N_c-1$

For comb type pilot based estimation for each transmitted symbol N_p pilot signals are uniformly inserted into $x(k)$. i.e. the total N sub carriers are divided into N_p groups, each with $L=N/N_p$ adjacent sub carriers

$$H_p L_S = [(X_p/Y_p)]^T \quad \text{Where } k=0,1,\dots,N_p-1 \quad (2)$$

B. MINIMUM MEAN SQUARE ERROR

The MMSE estimator employs the second order statistics of the channel conditions to minimize the mean square error and yields much better performance than LS estimators, especially under the low SNR scenarios. A major drawback of the MMSE estimator is its high computational complexity, especially if matrix inversions are needed each time data in X changes. It can be derived that

$$H_{MMSE} = R_H [R_H + \sigma_n^2 (X^H X)^{-1}]^{-1} H_S \quad (3)$$

Where, H_{MMSE} is the estimated channel by MMSE algorithm and H_S is the LS based estimate. R_H is the auto covariance matrix of H (channel conditions), σ_n^2 denotes noise variance.

4 IMPOSED PILOT

A novel method of superimposed-pilot-aided channel estimation is suggested in which is spectrally efficient. With the block fading channel assumption, a superimposed training scheme is developed by using the first order statistics of the data. Pilot intervals are not decided in advance. It is a time domain channel estimation scheme and it is suitable for fast varying OFDM channels. In this, firstly one OFDM block interval is spitted into equispace time slots and assumed that the channel varies negligibly during each slot. These slotted channels are temporarily estimated by LS estimators, and meanwhile optimum pilot symbols are proposed with respect to minimizing the trace of channel estimates' mean square error (MSE) matrix. Final estimates are obtained by smoothing those temporary results.

5 COMB PILOT

In a comb pilot the Part of the sub-carriers are always reserved as pilots carrying pilot symbols. Here mostly Frequency domain allocation-1D estimator sufficient for estimation and Interpolation is required Algorithm of Estimation may be based on LS, ML estimator and PCMB while Spectrum efficiency reduces due to additional pilot carriers and also the Bandwidth efficiency, it is also Suitability over medium or fast fading channel. Channel is assumed steady between two consecutive pilots.

6 RESULTS DISCUSSION

As Shown in the fig. 2 and 3 it is the graph of signal to noise ratio (SNR) versus bit error rate (BER). In each graph four different types of SNR vs BER shown. In four different SNR vs BER is for different modulation scheme like BPSK, QPSK, 16-QAM and 64-QAM.. Here Table-1 is comparing SNR vs BER for modulation scheme BPSK and QPSK for comb and imposed type pilot while Table-2 is comparing SNR vs BER for modulation scheme 16-QAM and 64-QAM.

Table.1

SNR vs BER for comb & imposed pilot of BPSK and QPSK

BER	SNR of imposed pilot (BPSK) (db)	SNR of comb pilot (BPSK) (db)	SNR Of imposed pilot (QPSK) (db)	SNR Of comb pilot (QPSK) (db)
0.1	3.7	3.6	4.5	4.4
0.01	4.5	4.5	6.5	6.2
0.001	6.3	4.5	8.0	6.2
0.0001	6.5	4.5	8.3	6.2

Table.2

SNR vs BER for comb & imposed pilot of 16 and 64 QAM

BER	SNR of imposed pilot 16 QAM (db)	SNR Of comb pilot 16 QAM (db)	SNR Of imposed pilot 64 QAM (db)	SNR Of comb pilot 64 QAM (db)
0.1	6.3	6.3	10.1	10.0
0.01	8.5	8.3	12.0	11.8
0.001	10.5	10.0	13.2	13.0
0.0001	12.0	11.0	14.0	14.0

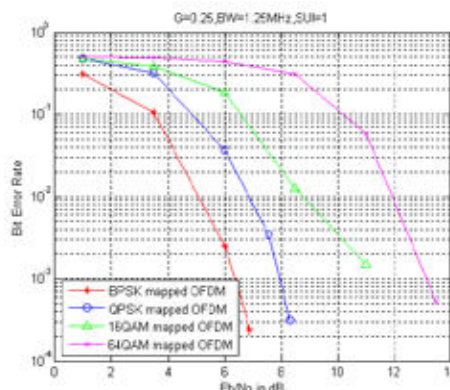


Figure 2 SNR vs BER Of imposed pilot

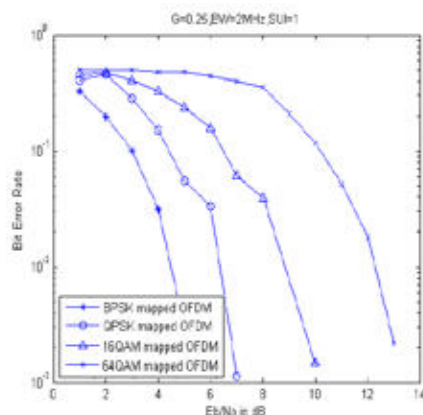


Figure 3 SNR vs BER Of comb pilot

5 CONCLUSION

In this paper we analyze the comparison of pilot base adaptive channel estimation for MIMO-OFDM system. From the description related to pilot considerations and results it is concluded that more number of pilots may be advantageous or disadvantageous depending upon availability of bandwidth and frequency spacing. It can be concluded from that there is no advantage to BPSK since in that example it performs identically to QPSK but takes up twice the bandwidth. Here, we compare comb type pilot vs imposed pilot with different modulation schemes. Analyzing result we have seen that the imposed pilot base SNR vs BER is better than comb pilot base SNR vs BER with different modulation scheme.

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